A REPORT ON SOME ALLOCTHONOUS PEAT DEPOSITS OF FLORIDA[1]

PART I: TOPOGRAPHICAL

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(WITH DIAGRAM)

As an introduction to the following report[2] on the allocthonous peat deposits of Florida, it seems advisable to discuss, very briefly, the geological and climatic conditions which obtain in this region, in so far as they bear a significant relation to the deposition of peat.

The entire state lies wholly within the Atlantic coastal plain, which extends, as an area of varying width, from Long Island to Texas, and represents a region of more or less recent origin, generally flat or rolling in character, with little or no evidence of folding or faulting. A stratum of Vicksburg or later limestone forms a continuous deposit which is now covered with Pliocene clay or Pleistocene sand, the latter being predominant at the surface (4). The gently rolling country forms numerous depressions which are below the level of the water table, and consequently contain a permanent water supply in the form of lakes. In the case of depressions above this water table, or not sufficiently far below it to form lakes by the above-mentioned plan, the limestone may be locally dissolved so as to form an outlet for the continuous underground water system, and in the manner of a natural artesian well a body of water is maintained to which there is no apparent external inlet. This condition is illustrated by the well known Silver Springs near Ocala. There are many other instances, also, where the limestone strata may have been locally dissolved by the action of surface or underground water

[1] Contributions from the Laboratories of Plant Morphology of Harvard University.

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to such an extent that it is not able to support the superincumbent sand or clay, which, falling, leaves a bowl-shaped valley. Depressions thus formed may contain more or less permanent ponds, known as "lime sinks," which are often important as sources of peat. Examples of this type of lake production will be mentioned in the later discussion.

Reference to any good map of the United States will show that there are more lakes in Florida than in the remainder of the coastal plain, the larger number of which, curiously enough, occur in the higher or central regions of the state. These lakes vary in many respects, but may conveniently be divided into 5 classes, as follows: large deep and large shallow lakes of irregular outline; small deep and small shallow lakes of more or less circular outline, and filled lakes which may present an outline characteristic of either of the two previously mentioned types. There is a great variation in size, from Okechobee, which is the largest lake wholly in the United States except Lake Michigan, and Lake Apopka, with its 62 miles of coast line, to those which are only a few rods in diameter.

The semitropical climate of Florida is very favorable for the growth of peat-forming plants. There is an average temperature of 72° C., with a more or less uniform variation from January with a mean of 58° C. to that of 83° C. in July. The average rainfall is about 49.6 inches per annum, the greater part of which is precipitated during the warmer months. This condition compensates for the loss by evaporation during the summer season, and preserves a more constant level for the lakes than would be possible if the greater precipitation occurred within the cooler season of the year. The texture of the soil, also, is very favorable for the formation and stability of lakes, since the porous coastal plain sand at once absorbs the greater portion of the rainfall, which gradually seeks the lower levels to reappear as permanent bodies of water.

The object of the present investigations is to determine the relative amounts of allocthonous peat (that type of peat which has been deposited by a gradual accumulation of floated, drifted, and wind-blown vegetable material in permanent and more or less quiet bodies of open water), and of autochthonous peat (that type of peat which represents the amassing of successive generations of plants in the presence of a more or less constant, but stagnant and concealed, water supply, permitting the growth of peat-forming plants *in situ*). The methods for determining the relative distribution of these two forms of peat are those which were devised by DAVIS (1). Samples were taken with a sounding instrument, the Eberbach probe, invented by DAVIS, at one foot intervals, in sufficiently numerous localities in the deposits to show the average conditions. The samples were forced into cloth sacks, after a superficial study of the gross characters, and stored for subsequent investigation in water rendered antiseptic with carbolic acid or formalin. A study of the gross characters of the material is generally sufficient to determine the method of deposition, and reference to the microscopic results will be made only where such seems necessary for greater accuracy. These investigations have led to the same conclusions that DAVIS (2) reached in regard to allocthonous peat deposits in general in the United States, which he has stated as follows: "At the present time peat deposits of this type (lacustrine) are numerically more important than any other in regions where peat formation is most common."

In addition to the different types of lakes just described, there are other areas where peat may be found, namely, swamps, river estuaries, etc. Examples of these localities will be mentioned later.

Since the types of peat deposition fall so conveniently into two classes, they will be discussed separately, with special reference to the gross characters of the samples. Autochthonous peat (*in situ*) may be very varied, both in respect to composition and gross appearance, depending upon the species of plants which enter into its formation and the amount of oxidation that has taken place. For example, in those deposits which have been formed by the growth of *Cladium*, *Sagittaria*, Cyperaceae, etc., or, to be more general, where the peat is entirely herbaceous in texture, the samples appear as fibrous, light brown, spongy material in which the individual parts of the plants can be distinctly seen and separated. On the other hand, where the quality of the peat is of a woody nature, tests show a deep brown granular substance, in which there is much fine amorphous material intermixed with the more or less decayed woody substance. This granular property may be taken as evidence of the accumulation of *Taxodium*, *Ilex*, *Magnolia*, etc., which plants occur only in those areas which have become somewhat drained, thus permitting decay to act more readily than in the case of the more herbaceous forms. This condition naturally results in a greater reduction, and consequently a more amorphous content. It seems necessary to add that in the apparent *in situ* herbaceous peat there is much evidence of drifted material revealed by the microscope, which naturally places the major part of the saw grass (*Cladium*) and other marshes under the head of allocthonous rather than of autochthonous formations, with the exception of the upper two or three feet of the strata. In speaking of *in situ* herbaceous peat in the later paragraphs, therefore, reference is made only to the uppermost layers, and not to the deposit in general.

Apparently these two characteristics of herbaceous and woody autochthonous peat formations are owing to the natural sequence of their occurrence, for it is a recognized fact that when the water level becomes sufficiently low to permit the growth of the higher plants, those of a herbaceous variety are the first to appear, which naturally accounts for the presence of the grassy peats below the more woody species where both are present in the same region. These two characters also show another distinct difference in respect to the amount of decay that has taken place, resulting entirely from the presence or absence of a permanent water supply. In the herbaceous peats there occurs little evidence of decay because of the presence of a constant water covering, as well as natural plant acids which prohibit the oxidation of the air and the destructive action of fungi, thus preserving its spongy, fibrous nature. When, however, the continual accumulation of these plants has raised the mass to such a height that it is above water for a part of the year at least, the monocotyledonous plants give place to more woody dicotyledonous species, which build up a stratum of a granular quality. This granular property is due to the decayed state of the amassed vegetation, brought about by the action of the air and the enzymes of bacteria, which are permitted to work on account of a lack of permanent protection by water. The less resistant plant organs are consequently reduced to a structureless mass, together with a partial decay of the more resistant elements, thus presenting samples of a rusty brown plastic property, in which, however, portions of decayed wood, cuticular parts, and stigmarioid roots can still be seen.

Although these two types of woody and herbaceous peat appear to be distinct, they have been classed under the same head, owing to a similarity in origin, and the apparent difference is due only to the nature of the included plants and the amount of comminution that has taken place.

In contrast to this formation there is the lake or allocthonous peat, which occurs as a layer of finely divided plant material as well as entirely microscopic organisms on the floors of permanent and deep bodies of fresh water. This type owes its existence to the action of winds, currents, and sedimentation. Although the deep lake formed deposits bear a strong superficial resemblance to the much decayed woody peat, with the exception of a habitual absence of a granular content, they are in fact very dissimilar, since the deep brown, plastic character of uniformly fine texture does not represent the product of comminution of grosser parts of plants, resulting from oxidation and destruction by fungi, but rather the accumulation of originally minute organic material which has not suffered decay, owing to a permanent saturation.

Like *in situ* peat, lake formations may vary much in color. Those samples which are mostly organic in composition present a deep brown, uniformly fine appearance. Those, on the contrary, in which there is a large inorganic content may be red, pink, or gray. These latter colors are due to a more or less abundant silt, shells of infusoria, etc., which produce an admixture with the sedimentary, drift, and wind-blown material, imparting to it, where predominant, their characteristic hue.

As the writer has previously stated, the aim of this paper is to supply a brief account of the regions which were visited and a short description of the samples of peat collected in so far as they bear a significant relation to the methods of peat deposition in a semitropical climate. Reference to later microscopic investigations of the material will be made only where such seems necessary in order to form an adequate opinion as to the plan of accumulation in a special deposit. The general analysis of Florida peat, together with samples from Canada, New Hampshire, and Massachusetts, will be reserved for a later paper on the relation of the present lacustrine deposits to the formation of coal. The regions chosen for investigation were those which presented typical conditions in respect to topography and the flora now found upon the shores; an estimate of the extent of the several deposits is likewise included where such is possible.

The first deposit examined was at Lake Newnan, Alachua County, which represents a large deep lake with an area of about 16 sq. m. This entire body of water is surrounded by a sand plain bearing a scattered upland flora, which extends to the very shore, except at the southern end, where there is more or less of a marshy border. *Taxodium*, *Nyssa*, *Magnolia*, etc., grow abundantly on the banks, and there is a fringe of species of the Nymphaeaceae, *Sagittaria*, *Piaropus* (*Pontederia*) *crassipes*, and other deep water plants which extend several feet into the lake.

The lacustrine peat deposit was tested in 18 localities (diagram, 1–18), and samples were taken at one foot intervals which show the following characters: Those from the bottom are nearly black or deep brown in spite of a large admixture of sand, but there appears no coarse organic material except close to the shores, where the *Piaropus crassipes* has become a part of the mass. Above this foot of more or less gritty material there occurs a rusty brown, uniformly fine substance, becoming less compact and lighter in color near the top, and, as usual in such deposits, there is a characteristic absence of coarse material, except near the shores, where there is an addition of drifted portions of aquatic plants.

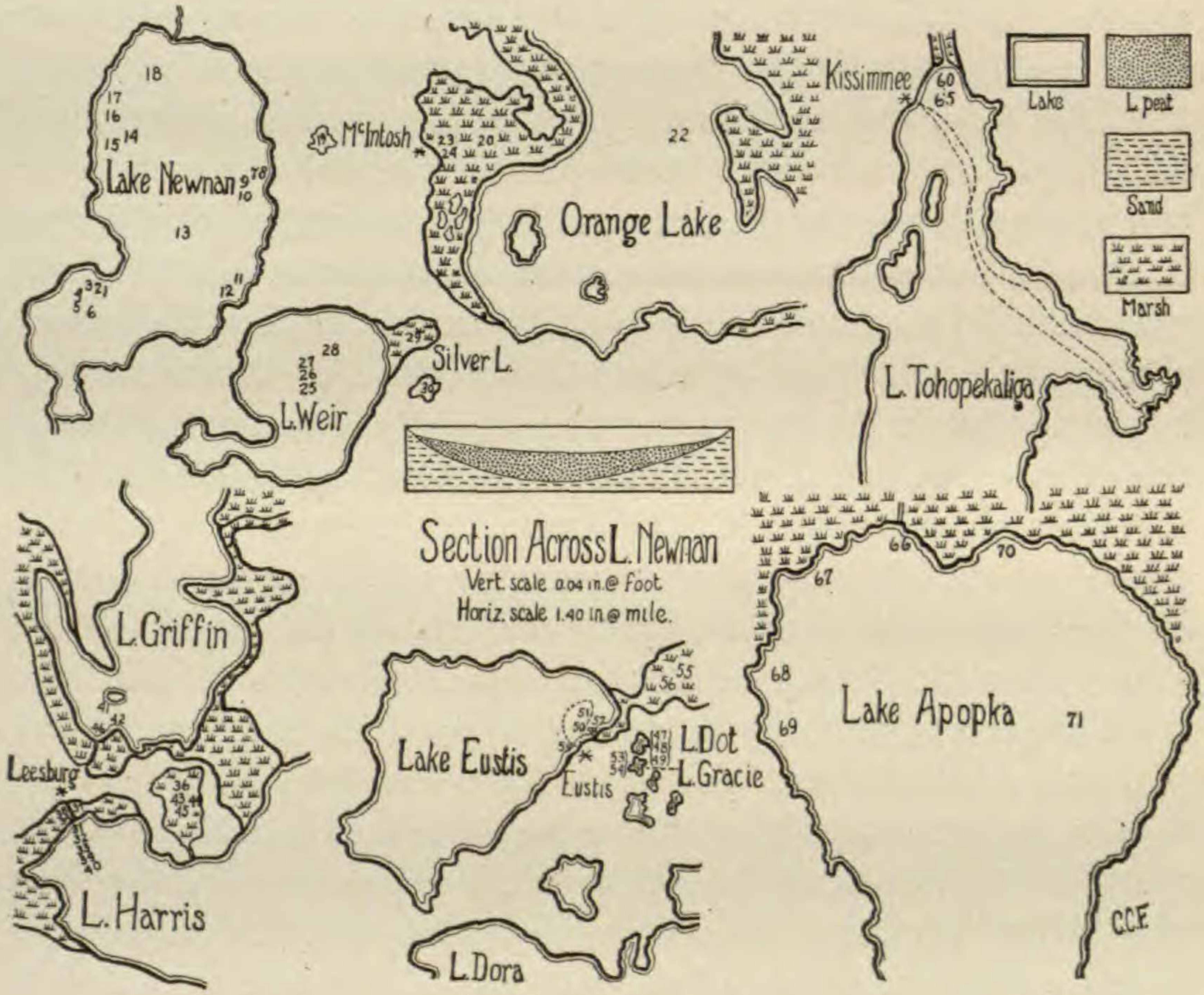
Some idea of the extent of this organic stratum can be obtained from a study of the cross-section (diagram), which was drawn to scale from the results of soundings in the center of the lake and other localities of varying distances from the shore (diagram, 1–18), the results of which can be learned from an application of the accompanying scales. Assuming that these tests are representative for the entire deposit, it is evident that there is a continuous layer of aquatic peat of varying depth extending over the entire floor of the lake, with the exception of the first few yards offshore.

Between Gainesville and Lake Newnan there is a hardwood and cypress swamp, representing the typical condition of fallen tangled logs, intermingled with finer plant débris. Upon investigation there appears only a few inches of peatlike material, which may be better characterized as humus, owing to the almost complete decay of the included vegetation. This type of swamp deposit proves to be very typical, and when compared with more aquatic formations is not of special importance from the numerical and quantitative standpoint.

The next investigations were made on a filled lake 2 miles west of McIntosh, in Marion County (diagram, 19). This represents a small shallow lake which has become entirely filled with herbaceous peat, composed of Cyperaceae, *Solidago, Eupatorium*, Gramineae, etc. The 10 samples at one foot intervals show a light brown fibrous material in which the individual plants can be seen distinctly. Upon a later microscopic examination it became evident that the lower two-thirds of the deposit is of allocthonous origin, a condition indicated by the presence of sponge spicules, as well as other evidences of drifted and sedimentary material which must have been laid down in a more or less permanent open pond. The upper stratum, however, has become reduced to a deep brown amorphous mass through the action of the air and fungi, following artificial drainage 25 years ago.

Orange Lake, as can be seen from the accompanying diagram, is bordered by a broad marsh on the western side. According to the reports of the inhabitants, the area of this marsh was used for cultivation 30 years ago, at which time it was inundated, and is now constantly covered with water. Species of the Nymphaeaceae, *Cladium, Sagittaria*, etc., grow there in profusion. A sample taken about a mile from shore (diagram, 20) presents a coarse brown fibrous character with the usual evidences of allocthonous material. Since this layer, 6 inches in depth, has been formed during the past 30 years, it may present some evidence as to the rapidity of the accumulation of fibrous peat, which would be at the rate of an inch in 5 years. Obviously, however, more data would be necessary to form a definite opinion concerning the building up of such deposits.

In the center of the lake (diagram, 22) a series of samples indicates a deposit 3 feet in depth, and tests in other parts show this to be a more or less uniform measure. In character the samples



A diagram to indicate the lakes mentioned in the discussion, each lake represented by a diagram enlarged from the map included in MATSON and SANFORD'S report (4), drawn to scale as accurately as the means at hand would allow; the small figures in the diagram represent the locality of each series of samples named in this paper, the relative position of which can be learned by an application of the scale in miles; the cross-section of Lake Newnan shows the average depth of the allocthonous peat deposit in relation to the breadth and deepness of the lake.

are very similar to those found in Lake Newnan. At the bottom there is a mixture of sand with the rusty brown fine material, with the usual absence of coarse fibrous matter, which generally occurs only near the shores. The upper portion differs from this only in a lighter coloration and less firm texture, and naturally enough without an admixture of sand.

On the shores at McIntosh there occurs a deposit, such as is often found on the shores of lakes, very much resembling lacustrine peat, as it presents a fine black structure, but it should not be confused with lake formations proper, for the reason that this condition is owing to the result of the action of the air and fungi on coarse fibrous material during periods of drought.

Lake Weir, Marion County, may be classified as a large deep lake, bordered by hills with their upland flora, which enter into the composition of peat in the form of wind-blown material only, that is, pine and angiospermous pollen, strips of epidermis, and deciduous fragments. The shores are of a sandy nature without the border of *Castalia*, etc., which is very characteristic of the previously mentioned lakes. Owing to the deepness of the water (30 feet in the central portion), it was difficult to determine the depth of the deposit with accuracy with the apparatus at hand. With what tests it was possible to make (diagram, 25–28), however, it became evident that there is no lacustrine material of an organic nature nearer than one-fourth mile from shore, but beyond this limit there appears a gradually increasing layer which is at least 5 feet in depth in the center of the lake.

A series of samples from this region differ very much from those previously observed, as those from the upper portion show a deep gray coloration which gives place to a pink below. There is no admixture of sand in any of the samples; all are fine, firm, and of a uniform texture. This gray and pink hue is apparently owing to the presence of an inorganic silt, shells, and crustacea, sufficient in amount to obscure the characteristic color of the normal allocthonous peat. In order to be more certain that this material is not entirely inorganic in nature, a microscopic test was made which showed, in addition to a large amount of silt and shell formations, sponge spicules, diatoms, plant fragments, pollen, and spores.

Since there was a possibility that a marsh, apparently a former arm of the lake, just north of the town of East Lake (diagram, 29), might show evidences of a transition of lacustrine to *in situ* peat, probings were made, which showed the deposit to be of a uniformly fibrous nature. The samples reveal the fact that the stratum is generally herbaceous and has been formed by the gradual accumulation of the plants which now grow upon the surface, among which Cyperaceae, *Solidago*, *Eupatorium*, etc., are the most abundant. The lower portion, however, showed evidences of an allocthonous origin on later microscopic examination.

Silver Lake, a small circular lake one mile east of the previously mentioned town, presents external characters very similar to those already described for Lake Weir. Many tests proved that the floor is of a uniformly sandy nature, with a general absence of allocthonous formation except a very shallow and gritty layer in a sheltered cove on the eastern side (diagram, 30).

Lake Harris, in Lake County, was visited next. This represents a large deep lake of irregular outline, bordered in many places by a broad saw grass (*Cladium*) marsh, as indicated by the shaded portion of the accompanying diagram. In many places there is a dense cypress swamp between this marsh and the rolling upland country, which gives place to hard woods where the shores are too steep to allow the growth of *Cladium* and other marsh-forming plants. Where the water is too deep to permit the growth of these species there occurs a fringe of *Castalia*, *Nymphaea*, etc., generally in more or less of a floating condition.

One-eighth of a mile from shore (diagram, 31) a series of tests showed some very interesting characters. The bottom layer of the deposit presents samples of a pinkish color, owing to the presence of silt, infusoria, univalvate shells, etc. The substance is of a firm, plastic nature, with the usual absence of coarse material, as was revealed by a microscopic test by means of which much fine plant material was observed. In addition to this fine material there appears a variety of univalvate shells, which are apparently quite characteristic of this region, since they were also found in material from Lake Eustis. There has been no opportunity to have the species of these shells determined, but there is a possibility that they are very similar to those which HARPER (3) mentions as identified by BRYANT WALKER, of Detroit, Michigan. In this report there are 25 species named, among which the genera *Amnicola* and *Planorbis* supply the most species. These shells have a tendency to disappear in the layer above the pink formation, and although this stratum is very similar to the one just described, there occurs a change from the salmon to a decidedly reddish hue, which in turn gives place to the rusty brown plastic peat already described. A striking uniformity in the several layers appears out to about three-fourths of a mile from shore, where there occurs a gray formation below the pink, an exactly opposite sequence from that found in Lake Weir. The several probings (diagram, 31, 32, 33, 39, and 40) showed that this laminated deposit varies in depth from a few inches at the border of the marsh to 9 feet a mile off shore, and when, too, the large area of this lake is taken into consideration, it is evident that, providing conditions similar to those found in Lake Newnan obtain (diagram, cross-section, and description above), there must be an enormous amount of allocthonous peat in Lake Harris.

Lake Griffin, just north of Leesburg, shows external conditions very similar to those already described for Lake Harris. Between the broad saw grass marsh and the upland pine plains there appears a dense cypress swamp which occasionally gives place to a dense growth of hardwood trees, among which *Magnolia glauca* and *Nyssa biflora* are the most abundant. There also appears the usual fringe of floating *Castalia*. Tests were made about a mile from shore (diagram, 41) near a small island, where the floor proved to be of a sandy nature, a condition very habitual for shallow water lakes, owing to a more or less constant agitation by waves. Soundings near the shore of the mainland show a shallow deposit of allocthonous peat, which gradually grows deeper toward the border of the marsh. A series of samples taken just outside the range of the deep water plants presents the following characters (diagram, 42 and 46). The deposit, unlike that found in Lake Weir and Lake Harris, is of a uniform deep brown quality, except for a stratum 2 feet from the bottom, in which the material is deep red, very loose in texture, and showing a tendency to break into a crumbling mass, in contrast to the more plastic claylike structure so commonly found in such deposits. The portion of the allocthonous layer above this red formation presents the usual deep brown plastic samples normally present in the upper strata of lacustrine peat.

Since the saw grass marshes were so abundant in this region, a description of the one bordering Lake Harris (diagram, 34, 37, and 38) may be of interest. The entire surface is now covered by an almost impenetrable growth of *Cladium effusum* (saw grass), *Sagittaria lancifolia*, *Spartina Bakeri*, as well as other marsh plants, which has gradually built up a deposit of light brown fibrous peat, which at the present time has attained a depth of about 10 feet. The samples show a striking uniformity in the lower 8 feet of the stratum, and the presence of sponge spicules, pollen, sporangia, diatoms, etc., show it conclusively to be of allocthonous origin. Owing to permanent saturation as well as natural acidity, the lower portion has not suffered decay, as can be seen by the spongy fibrous character of the peat; but, on the other hand, the upper 2 feet show the result of decomposition, for the reason that there has been a sufficient accumulation of plant material to raise this part above the low water mark, permitting decay to take place. Natural drainage has favored oxidation and comminution to such an extent that the original fibrous mass has been reduced to a deep brown, finely grained substance in which only the more resistant parts of the plants appear, imbedded in an amorphous matrix of the less resistant, and consequently more decayed, portions of the included vegetation.

Localities 36, 43, 44, and 45 (diagram, north of Lake Harris) represent a series of samples from a filled lake. Apparently, as a study of the material and the natural topography of the region will show, this was at one time either a separate lake or an arm of Lake Harris, which has since been filled by a gradual accumulation of plant material representative of both allocthonous and autocthonous forms of peat deposition. The surface, where it has not been disturbed, is now covered by a dense growth of *Magnolia glauca*, *Nyssa biflora*, *Pinus Elliottii*, etc., and in those portions where the growth has been artificially cleared species of Cyperaceae, Gramineae, Compositae, and *Eupatorium capillifolium* grow in profusion. The upper foot of this bed is in the form of a firm, black, consistent mass, owing to an almost complete decay of the included plants, as a result of artificial drainage. This upper layer might be considered as the initial stage in the formation of humus. Below this almost completely broken down stratum there is present a uniformly fine deposit of a decidedly woody nature, which appears as a deep brown granular accumulation of softened coniferous débris, nearly or entirely reduced to a structureless condition. Below this woody deposit there is quite an abrupt transition to a light brown herbaceous peat of the saw grass variety, similar to that described for the marshes on the shores of Lake Harris (diagram, 34, 37, and 38). This coarse undecayed deposit is underlaid by a fine, deep brown lacustrine formation and the absence of any coarse material, together with the unaltered condition of the samples (determined by later microscopic investigations), would indicate that this stratum had been amassed in the bottom of a permanent and deep body of open water by an accumulation of drifted and wind-blown plant material. At the bottom there appears a deposit of bluish gray clay.

From a study of the samples it is apparent that at the time when the lower 6 feet of fine allocthonous peat had been formed the amassed vegetation, as drifted and wind-blown material, had reached a sufficient height to permit the growth of herbaceous water-loving plants (a condition parallel to that represented by the constantly extending marshes on the shores of the adjoining and still existing lakes). When these plants had formed 2 feet of fibrous material, corresponding to the saw grass stage, another change took place, and this type gave way to a more woody growth. This last transition was owing to the fact that the allocthonous variety had so accumulated that the very upper portion of the deposit was above water for a part of the year, thus bringing about a condition favorable to the growth of trees. These gradually drove out the more herbaceous species, and, by the amassing of successive generations of woody plants, slowly built up a layer of autochthonous origin.

The next lake visited was Lake Dot, a small deep lake one-half mile east of Eustis, Lake County (diagram, 47-49). This body of water is situated in a circular depression in the form of a large bowl 70–80 feet deep and 200 yards broad, which naturally leads to the conclusion that it is of "lime sink" origin, formed by the gradual solution of the underground limestone. Although the lake is small in diameter, the water level is permanent and deep, thus affording excellent opportunity for the accumulation of allocthonous peat. The first series of samples were taken at a point about 100 yards from shore, where the deposit proved to be 10 feet in depth and situated under 8 feet of water. The bottom samples present a deep brown plastic appearance, in which there is no coarse material with the exception of a slight admixture of sand, which disappears a few inches from the floor. There occurs an exception to this uniformly fine plastic condition 2 feet from the base in the form of a light brown herbaceous peat 2 feet in depth. Apparently, when the character of the formation of the lake is considered, this sudden variation in the composition of the peat was caused by the opening of an underground outlet, which allowed the water to escape and rendered the lake sufficiently shallow to permit the growth of aquatic marsh plants. This is quite a common occurrence in this region, of which condition the Alachua sink (locally known as Paynes Prairie) near Gainesville furnishes a good example. To quote directly (4, p. 27):

> The Alachua sink is important because it illustrates some of the changes which sink holes undergo. In the early days of the state this sink, which receives the drainage of a large stream crossing Paynes Prairie, appears to have been in about the same condition as it is today; later, owing to the closing of the outlet, perhaps by logs and other rubbish, a large lake was formed. About 1891 the sink reopened and the basin was drained, effectively ending the steamboat traffic there had developed on the lake.

To return to the discussion of Lake Dot, it is apparent that after 2 feet of this herbaceous peat had been formed the outlet was closed (possibly through the amassing of the vegetable material to such an extent that the exit was filled, and the seepage and rainwater were prevented from escaping), and the level of the water was raised to its present position. This second transition killed out the herbaceous species, which are not able to exist in more than 10–12 feet of water (1). This condition is also emphasized by a return of the fine deep brown lake peat above this more fibrous stratum.

Lake Eustis, a large deep lake just west of the town of the same name, furnishes some interesting features. The shores are generally sandy with the exception of an occasional cypress swamp, but the broad saw grass marshes so commonly encountered around the lakes near Leesburg were generally absent. The northern portion was first examined, but no material was found, because the shallow nature of the lake in this region had prevented the accumulation of allocthonous deposits. A series of samples (diagram, 50, 51, 52, 57, 58, and 59) show the general character of the material near the shore. The basal stratum presents black, fine specimens of a decidedly sandy and diatomaceous nature, so commonly encountered in the lower layers of lacustrine formations. This black gritty mass soon gives place to a deep gray lamina of similar texture. The only coarse dĕbris found in this lake was an abundance of univalvate shells of the same species as those mentioned in the discussion of the samples from Lake Harris. In this bed of peat there appears no transition from gray to pink, as is the case in the adjacent lakes, but the gray stratum is overlaid by a deep brown, fine, plastic deposit without the intervention of other formations.

One and one-half miles east of Eustis there is a bog which may be classified as a small filled lake (diagram, 55 and 56). In gross characters this bog furnishes strata similar to those already described for localities 34, 37, and 38, and consequently may be considered as representative of like methods of accumulation and as having passed through parallel cycles of sedimentation. The deposit is now covered by a dense growth of species of *Pinus*, Cyperaceae, Gramineae, Polypodiaceae, etc. Samples taken in the usual way show the following qualities: The upper layer presents a fine, deep brown, plastic character, in which there is much evidence of partially decayed lignified elements intermixed with the less resistant, and consequently more reduced, portions of fallen plants. This type of structure is very uniform to about 9 feet in depth, where it gives place, as usual, to a layer of herbaceous peat. The basal region furnishes specimens of a fine black nature in which there is a large admixture of sand. From results obtained by a study of the soundings it is evident that this bed has pursued a filling process similar to that mentioned in the discussion of the filled lake near Leesburg. The lowest allocthonous peat was formed in deep open water, which condition continued until a sufficient mass of this type had accumulated to render the water shallow enough for the growth of herbaceous water plants. These plants gradually crept in from the shores until the surface was covered, and the accumulation of the remains of successive generations of aquatica, together with the drifted and wind-blown material, eventually raised the amassed substance to such a height that it was above the low-water mark. This condition finally resulted in a change of flora to that of a more woody type, which has since formed the upper stratum of the deposit, the *Verländung* of German authors.

Lake Apopka, in Lake and Orange Counties, was the largest lake visited, and conditions were found to be very similar to those already described for Lake Harris. The entire northern shore is fringed by a broad saw grass marsh, 4 miles in breadth, with a limited region of cypress and hard woods between this and the higher land, and locally, where this woody growth extends to the water's edge. The western shore is bordered by pine hills which extend directly to the shore without the intervening marshy areas. A series of samples from the edge of the *Cladium* marsh (diagram, 66) show material of a herbaceous nature, which is evidently composed of amassed *Cladium effusum, Sagittaria lancifolia, Castalia odorata, Scirpus validus*, etc., light brown and very fibrous in character. The basal portion, however, was of an allocthonous nature, in the form of a deep black, finely grained deposit, gradually becoming coarser in the upper strata. This material is situated above a deep gray marl. On the western shore, just outside the floating *Castalia* and *Utricularia* (diagram, 68 and 69), there appears a layer of fine black lacustrine peat over 20 feet in depth, and, as in other regions where similar formations occur, there is no coarse material present, but all the specimens are uniformly deep brown and fine, with a habitual absence of coarse gray or pink material. The eastern shore presents, instead of the fine allocthonous peat, a partially decayed bed of *Taxodium* and other woods of so firm a nature that it was impossible to force the probing instrument through it, and consequently samples could be taken only from the top, each of which presents a very coarse woody character. The presence of this type of peat formation a mile from shore (diagram, 71) would indicate that at the present time this lake is much larger than it was at some earlier period when this deposit was formed, since the plants which have entered into its composition can only exist in a partially drained locality, while at present there are 10 feet of water above the stratum.

Many small shallow lakes at Zellwood, Eustis, and Orlando were visited, but each one showed a sandy floor and a characteristic absence of allocthonous material. This condition is owing, apparently, to the more or less intermittent nature of the lakes in which periods of drought permit the destructive action of the air and fungi to break down what little material there may have accumulated during periods of greater precipitation. Then, too, there is the action of the waves, which keeps the water in a state of agitation and prevents the gradual amassing of plant débris which may fall or float into the lake.

An estimate of the extent of the peat deposits in Lake and Orange Counties is manifestly impossible when one considers that there are over 2,000 lakes in this vicinity which vary in size from Apopka, with its more than 60 miles of coast line, to those which are only a few rods in diameter. In order to make determinations with accuracy, it would be necessary to resort to a careful survey of each one individually, which is beyond the scope of the present investigations. Consequently, no attempt is made to give even the probable extent further than to state that the allocthonous deposits are of greater numerical and quantitative importance than those of an *in situ* character, a condition true, also, for the other regions visited in Florida. Further, when one considers the probable amount of lacustrine peat, both from the standpoint of the number of lakes and the extent of the deposits as revealed by probings in the chosen regions, one must infer that the allocthonous type of peat in these 2,000 lakes and surrounding marshes must be enormous, and, when compared with those of an autocthonous nature, their relative superiority is very striking.

Lake Tohopikaliga, Osceola County, represents a large shallow lake with an area of about 30 sq. m. In following the dotted line in the plan of this lake there appears no place where the water is over 10 feet in depth (the observations were made in November, 1914, at a time when the water was at a low level), which accounts for the absence of any peat deposits, except in sheltered bayous, where the action of the waves has had no opportunity of prohibiting the accumulation of plant dêbris. Many of the sheltered portions, also, present no material of an organic nature, since the shallow character of the lake and the large fluctuation of the water level cause them to be dry for a part of the year, at which time the amassed material becomes desiccated and oxidized and floats away at the next inundation.

The only region where peat was collected at Tohopikaliga was in a sheltered bay formed by the broadening of the inflowing creek (diagram, 60–65), where there appears a very shallow layer of sandy, drifted, sedimentary, and wind-blown allocthonous peat. Thus it is very evident that this lake presents conditions very similar to those found in the small shallow lakes previously mentioned, in that the bottom is sandy and there is a general absence of vegetable accumulations.

At Pablo Creek, Duval County, there is a broad marsh with an area of over 4,000 acres, entirely covered by a uniformly bluish black peat to the depth of 10 feet. This deposit evidently owes its existence to the accumulation of river drift and wind-blown material, in addition to the constant amassing of fallen herbaceous plants. The first 8 feet present a series of samples of a bluish color, in which there appears no coarse material. One very noticeable feature in this locality is a strong sulphurous odor, which may be due to the presence of an abundance of *Beggiatoa*. Below this fine plastic mass there is a thin stratum of woody material, probably representative of an ancient inundated forest, which must have grown at some time when the water was at a much lower level than it is at present, and on its subsequent rising this flora gave place to more herbaceous and more water-loving species. The very basal layer consists of a shallow deposit of fine lacustrine peat, which has been formed upon the blue clay floor of this ancient lake. The material from this region is now used for agricultural purposes, after it has been artificially dried and mixed with commercial fertilizers, and the composition thus formed is placed on the market as "prepared humus," which should be very valuable when one considers the paucity of such natural formations in the upland portions of the state.

From a study of the peat deposits of Florida it is evident that lacustrine formations are much more numerous and much more abundant than those that have been laid down *in situ*, that is, in bogs, a situation apparently due to two causes. In the first place, there are many large lakes in the central portion of the state which contain much allocthonous material, and perhaps cover a much more extensive territory than that represented by the low marshy areas. Moreover, in addition to the relative differences in area, climatic conditions favor rapid decay of all the fallen vegetation unless it is protected by a constant water covering, as is the case of the lacustrine formations, in contrast to the less constant, and consequently more exposed, marshy areas.

It seems to be quite universal that the large or rather the deep lakes contain peat deposits, consisting of drifted, sedimentary, and wind-blown material. Moreover, although their deposition is due to the same agents, and has taken place under similar conditions, the individual accumulations of peat may present considerable variation in respect to color and texture. The variation in color is due to the relative amounts of organic and inorganic material present in the strata, for those which are mostly composed of plant débris present a uniformly deep brown coloration; but, on the other hand, where there is a large admixture of an inorganic nature, the samples may show a gray, pink, or red hue, depending upon the characteristic shade of the included silt, shells, etc. The texture is generally fine and plastic, with an absence of coarse material, except near the shore, where there is an addition of sediment resulting from water plants. The consistency may vary, however, depending entirely upon its position in the stratum.

When these lake-formed deposits have been built up to a point about 10 feet below the average water level, species of the Nymphaeaceae, *Cladium*, *Sagittaria*, etc., appear and gradually lay down a coarse, light brown fibrous peat of an allocthonous nature. In this type there is little evidence of decay until the deposit has reached such a level that the upper portion is above water for a part of the year, when the destructive action of the air and fungi has an opportunity to partially break down the successive generations of marsh-forming plants to a more or less amorphous mass of an autochthonous nature. When this stage is reached finally, the herbaceous plants give place to more woody species which, by a constant accumulation of deciduous matter, bring about the formation of a deep brown layer of granular texture, resulting from the only partial comminution of the resistant lignified elements.

All the previously mentioned stages in the formation of filled lakes were seen, and Lake Weir may be chosen as representative of the initial phase, since the floor and shores are uniformly sandy, with the exception of a deep gray allocthonous deposit in its central or deeper portion. The eastern side of Lake Eustis represents an example of the second stage in the process, since there is a more organic stratum above the gray formation. Lake Dot shows a still further transition in the form of a border of grass along the shore and the presence of a few of the deeper water plants growing on the surface of the brown lacustrine material. A more advanced degree of invasion may be seen in Lake Griffin, where there occurs a quantity of allocthonous peat covering the deeper part of the lake, and already the extending *Cladium, Sagittaria,* etc., have formed a broad surrounding marsh, the outer border of which is in turn bounded by a dense encroaching growth of more woody species. The final stage in the filling process is indicated by the bog near Leesburg, where the grassy plants have long since covered the entire area, and are now replaced by a dense growth of lowland trees. Conditions similar to these may be seen in many of the smaller deep lakes in this region.

Shallow lakes, whether large or small, show a general absence of peat formations, owing to their intermittent character, which, during periods of low water, permits the oxidation and comminution of what plant débris may have gathered; and the agitation by the waves prevents the accumulation of wind-blown and drifted material, as well as the sedimentation of water plants where such occur on the shores.

Conclusions

1. There are two main types of peat formation, namely, those deposits which are represented by a gradual amassing of drifted,

wind-blown, and sedimentary vegetable material in permanent, open, and quiet bodies of water (allocthonous), and those which have resulted from a gradual accumulation of successive generations of plants *in situ*, in the presence of more or less permanent but concealed water (autochthonous).

2. Allocthonous peat is characteristic of deep permanent lakes and the lower portions of marshes; autochthonous peat is characteristic of the upper portions of marshes, the upper strata of filled lakes, and swamps.

3. From what studies it was possible to make in regard to the average extent of these two types of peat formation it is evident that those of a lacustrine character (allocthonous) are of vastly greater numerical and quantitative importance than those of an autochthonous nature.

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